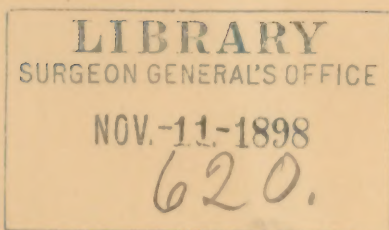


BROUGH (D.D.)

FORMALDEHYDE GAS AS A  
DISINFECTANT.





# FORMALDEHYDE GAS AS A DISINFECTANT.

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## FORMALDEHYDE GAS AS A DISINFECTANT.

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SINCE the discovery of the germicidal powers of formaldehyde gas this agent has been the subject of rigorous investigation by a large number of observers, both in this country and abroad. The most improved methods of scientific investigation have been applied to it. Many things are now known concerning the gas that are absolutely certain, while many of the extravagant claims that were first promulgated have been proved to be based on insufficient evidence. There are some questions that have not yet been satisfactorily answered, and more experience with the use of the gas will further enlighten us. In general, there has been a harmony in the results of all observers while there may be a wide divergence in some of the minor points.

It is simply my desire to present, as far as I am able, the value and limitations of this agent in practical disinfection, that have been drawn from practical experience during the year and one half in which formaldehyde has been used by the Board of Health of the City of Boston. I think that the Board of Health of this city has been among the first, if not the first, to introduce this gas in the routine work of municipal disinfection.

All the experiments that I have conducted have been carried on in the various dwellings of the city which have required disinfection on account of having contained some case of infectious disease. All the tests were made under condi-

tions as they actually occur. Having been made in the various houses, the results may differ in some respects from those performed in laboratories or especially constructed chambers.

The gas was discovered by Van Hoffman in 1868. He found that the vapor of wood alcohol coming in contact with finely divided platinum, gave rise to a product to which the name of formaldehyde was given. It is a product of the oxidation of methyl or wood alcohol. The oxidation results in the removal of the hydrogen from the alcoholic vapor forming formaldehyde. Its chemical formula is  $\text{CH}_2\text{O}$ . The gas can be prepared by bringing the vapor of wood alcohol properly mixed with air into contact with a metallic powder heated to dull redness. The contact of the alcoholic vapor with the metal continues to keep the metal heated. The substances most used are platinum, copper, iron-oxides and coke. The most active substance is spongy platinum or platinum black.

The gas is colorless, has a penetrating pungent odor, and is extremely irritating to the mucous membrane of the eyes, nose and throat. Its specific gravity is about the same as air. It renders gelatine insoluble and coagulates albumen when in the solid form. When added to a solution of serum albumen it prevents coagulation by heat. Pieces of meat exposed to the gas have been preserved for a long period of time.

The odor of formaldehyde is easily dissipated by the evaporation of ammonia. After disinfection the odor of formaldehyde can be neutralized by injecting a little ammonia into the room. By cooling, the gas can be mixed with water up to the proportion of 40% by weight of the gas. It is in this saturated aqueous solution that the gas appears in commerce under the name of formalin.

When the aqueous solution is allowed to evaporate in the air it becomes concentrated, forming a substance known as

para-formaldehyde, which is a union of two molecules of formaldehyde gas, and when further concentration goes on a white amorphous powder, known as trioxymethylene, is formed. This latter form is supposed to be composed of the union of three molecules of the gas. From both these polymerized forms the gas can be derived by the application of heat. The antiseptic and germicidal powers were, it is said, first noted by Trillat of Paris in 1888, and in 1891 an account of these properties was published by him.

The disinfection of rooms is performed by formaldehyde in the gaseous state. This gas can be obtained in several ways :

1. By means of lamps directly from wood alcohol.
2. From the solid form.
3. From the solutions of formaldehyde.

But from whatever form the formaldehyde is obtained, the results are derived from the gas that is generated. The various preparations in which formaldehyde appears, and the different kinds of apparatus, are but convenient methods of utilizing the gas.

#### DIRECT GENERATION OF THE GAS.

Probably one of the first lamps in this country for the generation of the gas on a scale sufficient for general disinfection, was devised by Prof. Robinson of Bowdoin College. There are many modifications of this idea on the market.

In general, the principle is to bring the vapor of wood alcohol properly mixed with air in contact with platinized asbestos which is thoroughly heated. This method has been tried in this city and in others but has now been generally discarded. The objections to this process were the dangers of fire, the difficulty of knowing whether the apparatus was working properly when shut up in a room, and the difficulty of bringing the vapor of the wood alcohol directly in contact with the platinized asbestos disk. After being used for

some weeks in this city it was given up. While good results have been obtained from experiments with this method, it was found impracticable for municipal disinfection.

With the generation of the gas from the combustion of paraform pastilles, I have had no personal experience. The excessive cost of this method would be almost prohibitory for its use on the scale demanded by municipal disinfection. In the hands of those who have used it, excellent results have been obtained. The conclusions were about the same as have been obtained by deriving the gas from the aqueous solutions. It is, however, a neat and simple method of obtaining the gas.

The gas can be obtained readily from the 40 per cent. aqueous solution. Disinfection in small closed spaces can be accomplished by allowing the solution to evaporate in open vessels or pans, but only a small portion of the total gas is given off. This is due to the fact that polymerization occurs and the solution becomes concentrated into the solid form and little gas is given off. In larger rooms this method would be wasteful and unsatisfactory. In laboratory tests fair results have been obtained.

Dr. Kinyoun of the Marine Hospital Service could not obtain satisfactory results in disinfecting rooms by saturating clothes with formalin and allowing the solution to evaporate in the room. In some late experiments by the Chicago Board of Health it is claimed that sheets, wet with the solution, suspended in the room and allowed to dry, gave as good results as other methods. The inconvenience of this process in dwelling-house disinfection has prevented any tests being made in this way. Nor can disinfection be accomplished by mixing formalin and water and simply heating the mixture in a closed vessel not under pressure. In the tests of Dr. Harrington of Boston at the City Hospital, the results were unsatisfactory and no disinfection was accomplished. A large amount of the formalin

became polymerized at the bottom of the vessel. It is necessary, therefore, owing to the fact that polymerization occurs, that some form of "regenerator" should be used of which there are a number on the market. We have used two forms. In one the aqueous solution is heated in a closed cylinder until a pressure of three atmospheres is attained and then the gas is allowed to flow through a tube and pipe, which is passed through the keyhole of the door of the room to be disinfected. In the other form the solution passes from the cylinder into a copper tube which is coiled over a lamp, and then becoming superheated the gas passes through the tube and pipe through the keyhole of the door. The first form has been preferred, as it discharges a very much larger amount of gas in the same period of time, and is not so liable to get out of order. The second form, however, obviates any danger of explosion which may possibly occur in the first method. It has never been found that with care, there was any danger of explosion. These machines are kept outside of the rooms and their working can be observed by the operator. We have found no benefit whatever to result from mixing the formalin with calcium chloride over that of the simple 40% aqueous solution. Other observers agree in this. It must be recollected that the disinfection is accomplished by the gas, and not by the apparatus as some manufacturers would have us believe. That form of apparatus is best which will conveniently deliver the largest amount of gas in the shortest period of time. Through the courtesy of Dr. Ernst I was enabled to perform this bacteriological work in the laboratory of the Harvard Medical School.

The tests were made of silk threads and gauze strips which were saturated with bacilli from twenty-four to forty-eight hours' bouillon cultures. Most of them were placed in the rooms in the dried condition, as it was desired to make the tests correspond as nearly as possible with the con-

ditions under which we would find the organisms in infected houses. Wet cultures were also used in many of the experiments. All the ordinary pathogenic organisms were used, but the diphtheria bacillus of a high toxine-producing power, and from fresh throat cultures, was regularly employed, as this is the known organism for which disinfection is carried on. Some tests were made with a non-pathogenic spore-bearing organism, and cultures were made from the dust of the rooms before and after disinfection. Freshly inoculated serum tubes of the various organisms were placed in the rooms, both open and plugged. Control cultures were made in every case, and in these growth was obtained in twenty-four hours.

The conclusions were drawn from the seventy-two hours' result in the incubator. The threads were placed in the nutrient media in the rooms directly after the disinfection with sterilized forceps.

Bouillon and Loeffler blood serum mixture, in tubes, were the media employed. The bouillon shows whether the disinfection was complete. On blood serum the amount of disinfection and the inhibitory effect of the gas could be more approximately judged by the number of colonies; microscopic examination was made in every case to determine the nature of the growths.

The general results were obtained from 36 houses, in each of which from 6 to 20 tests were made. The dwellings in which the tests were made were scattered throughout the city. The houses were of every description and variety, although most were among the poorer classes. The conditions were not favorable for obtaining the very best results, and the conclusions must certainly give a more approximate idea of the value of the gas than those carried on in absolutely tight rooms or under more favorable conditions. Nothing was removed from any of the rooms. The furniture, upholstery, bedding, wearing apparel and all other articles were

left in their places. Beyond spreading out the clothes and bedding, opening doors of cupboards and closets, opening drawers so that all surfaces might be exposed as much as possible to the gas, nothing was done in the way of preparation.

The crevices about the windows, cracks of doors, fissures in walls, loose flues and other places through which the gas could escape, were closed by pasting them with narrow strips of gummed paper. This is made for the Board of Health in rolls of about one inch wide. After closing the door and pasting the cracks, the gas was introduced through the keyhole.

The gas enters into the room in practically a dry condition. In repeated experiments no special difference could be noticed in the amount of moisture in the rooms before and after the introduction of the gas, as noted by the readings of the wet and dry bulb thermometers.

#### CONCLUSION FOR SURFACE DISINFECTION.

Whenever the gas in sufficient amount comes in contact with pathogenic organisms, they are invariably killed.

Spore-bearing organisms are killed with more difficulty than those that are not spore-bearing, and the results with non-pathogenic are not so constant as with pathogenic organisms. The position in the room makes no difference. Those placed close to the ceiling, those on the floor, and those at points midway between these, were equally sterilized. Threads stretched from the ceiling to the floor were completely sterilized. Currents of air near the test objects interfere with the action of the gas. In the experiments of Robinson and Bryant of Bowdoin College, and Dr. E. M. Parks of New York, threads that were placed on window sills or near cracks of doors were frequently found not to be sterilized.

The gas apparently acts equally well on both wet and dry cultures. This was my experience with silk threads

and squares of gauze. The same results were found by Parks and Robinson and Bryant. Dr. Harrington of Boston, in his experiments at the City Hospital, found that organisms on dry surgical dressings were completely killed, while with wet dressings only those on the surface were destroyed. Organisms growing in bouillon exposed in Petri dishes could not be killed.

The dust of the room was sometimes sterilized, sometimes not. A spore-bearing bacillus was frequently found not acted upon by the gas. The number of colonies in a measured quantity of dust was invariably found much larger before than after the disinfection. Generally after exposure only a few colonies were found.

Dr. McCollom, of Boston, in his experiments found that the gas acted as well on the discharges from nasal diphtheria and diphtheritic membrane as on cultures grown on artificial media, when they were directly exposed to the action of the gas.

#### PENETRATION.

In ordinary disinfection these tests would prove that the gas has very little penetrating power. It was the invariable result that cultures, whether wet or dry, when placed between mattresses, between pillows, between the folds of mattresses, in the centre of pillows, between the leaves of books and between solid objects, were not killed. When the organisms were wrapped up firmly in layers of blankets or heavy articles they were not rendered sterile; placed in pockets of coats and trousers, dresses, or wrapped up with light articles as sheets, handkerchiefs, etc., the organisms were sometimes killed and sometimes not. When placed in drawers left open slightly, they were killed; when the drawers were closed they were sometimes killed and sometimes not. When the threads were placed in the bottom of test tubes, and these tubes were left open in the vertical

position and exposed to the gas, growth was frequently found. When these same tubes were placed in the horizontal position, and the threads placed near the mouth, the organisms were killed. Freshly inoculated serum tubes, with the cotton plugs in, would always yield a growth. The same tubes with plugs out only gave slight growth at the lower portion of the serum slant. The opinion of all recent observers is that the gas is a poor penetrating agent under ordinary conditions. This is the conclusion of Dr. Doty of New York, Robinson and Bryant, Dr. Wilson of Brooklyn, Dr. E. M. Parks of New York, Drs. Harrington and McCollom of Boston, and others.

In experiments with absolutely air tight receptacles and bags and in the use of the gas by the vacuum method, with which I have had no personal experience, the penetrative power of the gas was found much greater.

Dr. Doty of New York has found that penetration is much increased with a vacuum. Dr. Wilson of Brooklyn was able *in vacuo* to kill organisms, even anthrax spores, in mattresses or wrapped in heavy blankets. Dr. Wyatt Johnson of Montreal has been able to secure complete sterilization *in vacuo* of objects in tightly rolled blankets. Robinson and Bryant, of Bowdoin, found with an excess of gas in air-tight bags, penetration could be secured through rather bulky articles. Other observers found similar results. Dr. Harrington says that "In presence of moisture the penetrating power is practically *nil*."

For penetration under ordinary conditions the gas has no especial value.

#### EXPOSURE.

In my own tests I have found no difference in results from exposures of 5, 6, 7 hours and upwards. As good results were obtained in the shorter period of time as in the longer. If the results with a certain amount of gas were

not satisfactory with a short exposure they never were with a longer. It would seem that the work of the gas was accomplished quickly.

Dr. Doty thinks an exposure of six hours is sufficient.

Dr. E. H. Wilson says: "It is preferable to allow the gas to remain as long as possible, but from three to four hours is sufficient for good disinfection." In surface disinfection he was able to kill the ordinary pathogenic organisms in four hours.

Dr. Parks, of New York, says: "The time of exposure not to be less than two hours, better to give four to six hours."

Dr. Harrington has found that "the organisms will be killed in from one half to three hours, varying with the amount of the gas used." Bryant and Robinson state that "the room should be closed from ten to twelve hours."

Dr. J. J. Kinyoun says: "The length of exposure is secondary to the amount of the gas, and a larger amount will give better results than small, even prolonging the length." He further states that fully twelve hours' exposure should be given. I think that most later observers in the main agree that as good results are accomplished in short exposure as in long.

#### INFLUENCE OF TEMPERATURE.

Within the range of temperature, such as occurs in ordinary disinfection, the gas seems to act perfectly well. With a low temperature, below 35° F., my results were not so satisfactory, even using large amounts, as with a higher temperature. It would seem that very low temperatures interfere with the action of the gas. Other observers have found that the gas is more active at a fairly high temperature. In general, the majority of observers have found equally good results between 50° and 110° F.

What is the amount of formalin necessary to generate gas sufficient to disinfect 1,000 cubic feet in ordinary rooms?

On this question there is a very great variance amongst different observers, even when using the same form of regenerator. Some have obtained complete results with very small amounts, while others using small amounts have claimed that formaldehyde was useless for disinfection. Most of the poor results seem to have been obtained from using too small amounts of the gas. With nearly air-tight rooms, or rooms where there is little absorbent material, we can get much better results with small amounts. In ordinary dwellings, where there is always considerable leakage, and where there is a great amount of bedding, upholstery, clothing and plastering which must necessarily absorb a large amount of the gas, very much larger quantities have been found necessary. Generally with small amounts of from 4 to 12 ounces to 1,000 cubic feet, I could not get very good results; occasionally they would be good. But on increasing the amount the results were much better. To get satisfactory results in house disinfection, I agree with Dr. Wyatt Johnson of Montreal that at the very least one pound of formalin to 1,000 cubic feet should be used, and it would be better to use even considerably more. In this city it is the custom to use nearly a quart to the 1,000 cubic feet, and the varying and inconstant results with small amounts have not been repeated.

#### INFLUENCE ON HOUSEHOLD GOODS.

In our experience in this city there has never been any injurious influence exerted by the gas upon any article of household furniture, clothing, bedding, upholstery, carpets, or on any ornaments, pictures, gilding, or on wall papers. Further, no person has complained of the gas causing any injury to his goods, and this after the use of formaldehyde in many hundreds of houses in all grades of society.

Dr. Kinyoun, in his experiments with 225 samples of wool, cotton, textile fabrics, hair, fur and leather, found

them unchanged by the gas. Colors are not affected with the exception of the aniline color fuchsine which is changed to purple; all other observers practically agree in these results.

#### INFLUENCE ON ANIMAL LIFE.

Our opportunities for observation in this line have been limited. Dogs and cats which have been left in rooms were found killed. Flies were invariably found dead. Bed bugs, which were exposed to the direct action of the gas, were likewise killed.

Drs. Harrington and McCollom both found that the gas was fatal to rabbits. The early claims of the innocuousness of the gas to all animal life have not been substantiated.

#### IN CONCLUSION.

I believe we have in formaldehyde the best practical gaseous surface disinfectant known. For dwelling-house disinfection it is unsurpassed. It is easy of application, and does no injury to goods. It is not ideal, its use being limited to surface disinfection. Its penetrative powers under ordinary conditions are so slight as to be almost valueless. Good results are best obtained by using a large body of gas, and having the room as tightly sealed as possible. Length of exposure and the influence of temperature are secondary to the amount used.

Under these conditions disinfection may be regarded as complete after the use of formaldehyde.